Thinking Technology in order to think engineering education

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Université de Lyon
INSA de Lyon, LEPS- STOICA, EA 4148

Introduction

Our world, in its step of "hyperindustrialisation", faces what could be called the paradox of technology. If our world is conceived by technologies, they are neither questioned nor thought. Our institute, the National Institute of Applied Sciences of Lyon, does not escape from this paradox. Its aim is to educate engineers by teaching them the use and the design of technical tools whereas technology is not a matter of thought: there are no courses in history of technology or epistemology of technology and the link between science and technology is not questioned.

In the best case, the question of technology is reduced to an ethical point of view and to the question of sustainable development. Usually, theses courses are founded on a common, transparent, representation of technology. Technological action and technology seem obvious and are reduced to human productions which are the result of a simple and mechanical application of science.

According to us, such a point of view is wrong and dangerous in a context where economical but also academic competition is harder and harder at the national and international level.

We think effectively that in such a context, technology is becoming an important field of research which aims at thinking technology as a principle and an object of science. ..

First, we will define the various meanings of the word "technology" and the history of this concept. Then, we will point out our definition of the word "technology" which implies others relationships between science and technology. Finally, we will show the implications of such a definition upon engineering education.

Technology: history of an idea

In order to understand the inversion of point of view we proposed it is necessary to consider Technology from an historical perspective. Indeed, in the Greek culture, technology has been thrown out of the Logos. It is not considered as an object or a principle of science (Detienne, Vernant, 1974).

Nevertheless, the first steps toward a technology can be found in the French Encyclopaedists project which aims at gathering the technical knowledges of their time. This project can be considered as a descriptive technology. It opens the way to the elaboration of the concept of technology by Beckmann in 1770. According to this author, “technology is the science which considers artefacts as the result of a process.

Then, in his book, *Elements of technology* (1829), Jacob Bigelow systematizes the use of the word “technology”. Technology is reduced to an application of science and since the Industrial Revolution the aim of science is to produce technological applications. This conception has been strengthened by inventions as the atomic bomb during WWII. Then, defining technology as an application of science does not lead to consider it as an object of knowledge (Sigaut, 1987).

Among the first authors who try to consider technology as a science, André-Georges Haudricourt defines technology as a science of human activities. This philosophical point of view has been re-updated in France in the nineties when technology is seen as a human science (Perrin, 1991). The project of elaborating a science of technology is not new and has been considered from multiple points of view. Curiously, there is a point of view which has not been considered: the rationality point of view whom we think it could lead us to think differently engineers curricula.

Technology as a science of creative rationality

Let us note the fact that, in the Occidental history of ideas, there are various forms of rationality. Vico is indeed the first philosopher who tries to describe this kind of reason. In his book *De studiorum ratione*, he describes the “ingenium” as the faculty to understand the relationships which can exist between separate elements of reality. For him, the “ingenium” is the source of poetry and scientific invention. It is a thought which establishes relationships between separate things or concepts. It is an open way of thinking which invites us to make the experience of newness, and is the source of innovation. As Vico says, none of the big technical inventions which changed the face of the modern world are the product of the analytical reason.

Ingenium is a form of rationality which does not separate but ties, which does not separate imagination from reason, binds them in a process of creativity. It is the faculty of all the people who bring nearer distinct worlds. It is the faculty of the designers who, for example, use materials of furnishing in the design of glasses. So, the “ingenium” is not the kind of thought used by specialists

Such a point of view seems to be confirmed by B. Jacomy when he explained that people who introduce the most surprising invention are not often specialists. The last example is the one of Roland Moreno who invented the electronic credit card and was not a computer specialist but a journalist! (Jacomy, 1994). Nevertheless, if Vico is the first philosopher who tries to give a description of this kind of rationality, the “ingenium” or the “metis” are forms of an ambiguous rationality which, in the Occidental history of ideas, is hidden and pushed outside the field of scientific knowledge.

Our present research work tries to understand this creative rationality in order to propose a modelisation of it because we think that “ingenium” is the rationality used by engineers. H Vérin writes: “the main characteristics of engineers, from the Greek mechanics of Antiquity, has always been to establish relationships between heterogeneous forms, materials, forces, figures, sizes so as to produces news effects.” (Vérin, 1993: 16).

Actually, we attempt to make a description of its main characteristics.

First of all, this kind of reason does not try to think the essence of various realities thanks to analytical method, it aims at thinking not the being but the time, not the essence but the process, not the eternity but the becoming of things.

Secondly, this reason invites us to make links and analogies between separate concepts belonging to separate fields of knowledge. To think it, we shall use “an hermeneutic circularity” which invites us to refer to an interdisciplinary approach in order to try to think and make a modelisation of it. Finally, another main characteristic of this creativity is to be transverse. It links opposite concepts but also opposite attitudes: thinking and acting for instance. This is why thinking creativity leads to be creative and reciprocally.

Creative rationality and engineering education

To consider creative rationality is not a pure theoretical stake Our research work has pedagogical implications. It leads to abandon the kind of contemplative, dogmatic, analytic rationality which is usually taught in the engineering departments of Universities as if techniques were a mere application of a contemplative, essential science.

Paradoxically, it seems that engineers formations are more concerned by analytical rationality than by the creative one (Faucheux, Forest, 2007). Engineering formations have been based largely on the applied sciences model (the name of our Institute is a good

example: “National institute of applied sciences”). The first two years of the curriculum are devoted to the teaching of a solid basis in essential sciences.

Such a choice is curious. According to us, Engineering Universities, far from appearing as places dedicated to the application of sciences, should not forget to be places of the “ingenium” training. For instance, we need engineering formations which help to develop creative rationality. And, in the same way, the process, the art of design which is widely considered to be central in the activity of engineering implies to use a creative rationality. Besides, in Technological Universities there is now a tendency to teach students how to get a job into a company and to neglect the understanding of the design of technical objects. Teaching creative rationality also implies to leave a way of thinking which privileges, on the one side, the analytical rationality and, on the other side, the instrumental approach of knowledge, which refers to a representation of technology as a mere application of science.

In other words, to import creative rationality in Technological Universities implies to invent a new kind of engineering formation. It also implies to invent new kinds of social and human sciences which would be specific to these Universities and will develop among the students the knowledge of technical objects, of technology, the understanding and the use of the process of creativity. So, students in engineering, throughout their scientific and humanistic studies, would be encouraged to find and develop their own way of thinking, to be creative themselves and at the same time, to understand the process of creativity.

The teaching of creativity leads to draw a new cartography of knowledge, to develop interdisciplinarity in order to point out that the process of creativity is the same in the development of arts, sciences and techniques. A new kind of courses showing the analogies which can exist between history of sciences, techniques and arts, would help, for instance, the students to understand such a matter of fact.

Finally, our research work allows us becoming aware that education for engineers cannot be the transposition of academic courses as taught in Universities giving a general education. On the contrary, the education of engineers needs to be shaped in a specific pedagogical way which should characterize engineering universities. Besides, it needs to educate the students to be creative which also implies to develop pedagogical innovations, a pedagogical creativity. This aim implies to develop interdisciplinary approaches of knowledge.

Conclusion

Thinking technology, as we said, implies another kind education for engineers. We can consider that Engineering Universities can appear as a true laboratory for social and human sciences from the double point of view of research and teaching.

Besides, we think that thinking technology can be a way to open a new field of research: the researches in social and human sciences in the Engineering Universities and draw a new cartography of knowledge, drawn by another kind of rationality, the creative rationality.

Finally, such a research can offer the possibility to question the emergence of innovation and give a model of the process of creativity.

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